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Practical Engineering.

A paper was read before the Society of Practical Engineering Feburary 3d, by Charles J. Moore, C. E., on the defects and merits of city pavements. The lecturer divided his subject into three principal divisions, first, a description of the various systems of pavements in use; second, the opinions and experience of various city engineers throughout the country; and, third, the practical deductions to be drawn, including the desiderata for a perfect pavement for city streets, and the various descriptions of pavements best suited to specific localities. The various systems of pavements were classified as follows: 1.—Stone-block pavements, including ancient Roman pavements, the modern Belgian block, and common granite block, and rubble, bowlder, or cobble-stones. 2.—Broken stone pavements, including Telford's system, an inelastic roadway, and Macadam's, or one partially elastic. 3.—Concrete pavements. 4.—Asphalt pavements. 5.—Wooden pavements. All these varieties were carefully described, and the modes of construction explained. In the second division the lecturer gave an account at length of the experience gained in the use of various kinds of pavements in the cities of New York, Brooklyn, New Haven, Cleveland, Louisville, Chicago, and St. Louis, and showed how some systems of pavement, inapplicable to certain cities, were found to be suitable for others. The principle varieties of pavement used in the different cities are limestone and granite blocks, in St. Louis wood being condemned, but Telford recommended; in Chicago, wood pavements exclusively; in Louisville, Macadam pavements chiefly, but wooden blocks likewise; in Cleveland, sandstone blocks, and stone and wood combined; in New Haven, Telford pavements; in Brooklyn, cobble stone or bowlder pavements, with granite blocks for the principal thoroughfares.

Street pavements were then considered practically from a sanitary point of view, in which it was shown that dust was unhealthy as well as uncomfortable; noise was detrimental to nervous sufferers; defective cleansing was dangerous, owing to the consequent deposit of foul matter, whence noxious gases arose. The form and character of pavements were shown to have most powerful effects upon the force necessary to draw loads over them, and upon the endurance of draught animals and vehicles. In describing the various kinds of pavement suitable for special localities in cities, the lecturer commended for those streets with heaviest traffic, stone-block pavements with stone tramways laid down of the ordinary guage of wagon wheels, and as many in number as the width of the street would accommodate. For second-class streets he recommended asphalt or bituminous concrete; for the third-class, Telford or concrete pavements, *i. e*, for the suburban districts and places where traffic was lighter; and for the fourth-class of streets, or those leading from the city into the surrounding country, wooden blocks or Macadam, especially the latter. With a few remarks upon the construction and covering of sidewalks, cleansing machines, steam versus horse-power, road-rollers, &c., the lecture was brought to a close.

Mr. E. A. Leland, M. E., read a paper on Sanitary plumbing, in which he described various plans of ventilating and constructing water closets to prevent the passage of foul and noxious vapors into the interior of dwellings, &c., and new methods of plumbing, by which the common defects and great expense of making joints in pipes may be obviated.—*N. Y. Times.*

A prize of one thousand dollars has been offered by the Franklin Institute to any resident of North America who shall determine by experiment whether or not all rays of light are transmitted with the same velocity.

No. 1906 Pine St., Philadelphia, Pa.
February, 20th, 1876.

Editor News:—

Dear Sir. The subscriber is engaged in preparing a general treatise on American Tunnelling, to show both our record in the past and the present methods in vogue.

No work of the kind has ever been compiled in America, and the only English record is Mr. Simm's account of the method adopted in the construction of two tunnels in 1844.

For every new tunnel that is started, Engineers are generally put to a vast amount of unnecessary trouble in looking up records of tunnels wherever they may be found, so as to determine on the most advisable cross-section to adopt, if in rock; and what thickness of masonry has been deemed advisable in soft ground; what rate of progress has been attained in various materials, and at what cost, etc., etc. Except in the case of a few isolated papers, read before our engineering societies, there are no authentic printed records attainable.

Now if Engineers throughout the country will assist in the work of collecting data, and will kindly forward any facts in their possession, the combined information, if properly collated and arranged, would be of much value. To this practical record of American work will be added a condensed record of the history of European Tunnelling, now being prepared abroad, with tables showing the location, length, cost, rate of driving, machinery used, etc., etc., in the construction of the principal tunnels abroad. Returns of South American work have also been applied for, which will be especially interesting, owing to the little that is specifically known of the heavy work done there of late years.

Will you kindly assist in the work, by sending any data, never mind how small, or in what shape, you may have and can conveniently forward? Should you desire it, their safe preservation and return will be guaranteed on receipt. Below please find a general scheme of the subjects treated, it being proposed to cover not only large Railroad Tunnels proper, but also mining adits and drifts, canal and water-supply tunnels, etc., etc., the work to be ready for press probably during the summer or autumn of 1876.

Any data solicited concerning railroad tunnels, or mining tunnels, headings and drifts, as to their,

1.—Location, length, date, time occupied in building, etc., etc.

2.—Names of Engineers and Contractors.

3.—Nature and characteristics of materials passed through.

4.—Cross-section adopted through the rock where self-supporting, and if loose, method of timbering, and cross-section of masonry.

5.—If of rock whether top or bottom heading driven, with rate of progress and size of heading, whether driven by hand or machine labor. If by hand, number of hammers generally employed on a shift, and number of shifts per day preferred. If by machinery, what make of drill and compressors adopted.

6.—If drilling by hand or machine labor, estimate of cost per cubic yard or lineal foot, or both, of heading and enlargement. If work commenced by hand labor and machinery subsequently put in, relative rate of advance, and relative cost.

7.—What explosive used, and any details as to amount burnt per cubic yard of rock broken in heading and enlargement.

8.—Manner of working and rate of advance of enlargement in rock.

9.—If through soft ground, (*i. e.* clay or deposit) size, rate of advance and manner of driving, timbering, etc., preliminary (top or bottom?) headings, with details of subsequent enlarging and arching. Cross-section of masonry adopted. Description of stone, brick, or cement used.

10.—Final grades and drainage adopted.

11.—If shafts or slopes used, any details concerning their sizes, material passed through, rate of progress, etc.

12.—What depth of open cut deemed advisable at either extremity (rock or earth cut?) before beginning to tunnel.

13.—Price paid, or final cost, per cubic yard, of tunnel and shaft excavation.

14.—Price paid, or final cost per cubic yard, of tunnel masonry.

15.—Total cost of work.

Lastly, if this should reach the hands of any gentleman not personally connected with tunnel work, any information whatever, bearing even most remotely on the subject, is requested; *i. e.* the locality of any tunnels,—naming the railroad or mining district, so that specific information may be sought. Or reference to any publications on the subject of tunnelling, whether in scientific periodicals (American or foreign), or even in the daily papers. Address,

Henry S. Drinker, *Mining Engineer.*

The Poughkeepsie Bridge.

The contract price of this bridge is $3,412,000; of this $500,000 in stock subscriptions are to be raised before April 21st in order to bind the contract. The total stock is to be $1,000,000, but work will be commenced when $500,000 is raised, and the other half million is assured. The remaining $2,412,000 will be taken by the contractors in bonds of the company at par.

The following is the description of the bridge as recited by the contract:

The contract entered into by the special committee of the Poughkeepsie Bridge Company with the American Bridge Company of Chicago, was signed Friday, February 11. The main river bridge will be composed of five spans, of 525 feet each, from centre to centre of piers, each span having a clear width of 500 feet at water line. The river spans and approaches are to be built for two tracks, with sidewalks and iron hand-rails throughout, and when completed the structure will be what is termed an undergrade or deck bridge. The five river spans are to have each two trusses, twenty-five feet from centre to centre, built on the rectangular plan, with double intersections, constructed of iron and steel combined. The base of the rails, whtch will be of steel, will be 193 feet above high tide, and the top of the piers 135 feet, giving a depth of trusses of 58 feet. Approaching from the west there will be a short span of 160 feet, composed of two trusses 30 feet high and 25 feet apart from centre to centre. Leaving the river spans on the east the tracks will be supported by iron trestling, consisting of three post bents properly braced, and four lines of iron lattice stringers in spans from 50 to 60 feet, extending to Water street, Poughkeepsie. Water Street and the grounds of the Hudson River Railroad Company, and also Dutchess avenue, are to be crossed by two spans having three trusses of 26 feet in height, and the remaining distance to the easterly side of Talmadge street will be upon iron trestling, except at Delafield and Talmadge street crossings, where the spans will be 90 feet each The total length of the bridge and its approaches will be 4500 feet. The river piers are to be built on wooden caissons, 40 by 80 or thereabouts at the base, with working chambers from 8 to 10 feet in height, the same to be sunk into the bed of the river by the pneumatic process, similar to the mode followed on most of the Missouri bridges, the St. Louis, and on the East river bridges. It will be so arranged on scientific principles that all of the water, mud, etc., will be forced out of the working chambers, and in their stead the chambers and caissons will be closely packed with the concrete. The pressure on the timber platform will not exceed five tons per square foot. The piers are to be first-class ranged masonry, and will finish at the top 11 by 37 feet.—*Boston Post.*

Full and trustworthy reports of Compass Variations for both upper and lower Michigan and many points in British America are to be found at the U. S. Lake Survey office, Detroit, Michigan.

The recent careful test of a gas meter proved to the satisfaction of all the parties concerned that it was found to over-calculate the consumption of gas sixty per cent. There was no reason, judging from the mere casual inspection of that one particular meter, to suppose that it was more defective and untrustworthy than the thousands of similar agencies employed in arriving at an estimate of the amount of gas consumed by those who are furnished with them by the gas companies.—*New York News.*

THE SEWERAGE OF BOSTON.

Plans and Estimates for a Complete System.

A Report by a Commission, Consisting of E. S. Chesbrough, C. E., Moses Lane C. E., and Charles F. Folsom, M. D.

[CONCLUDED]

POSITION OF SEWER OUTLETS.

In order to ascertain the best position for the outlet of a main intercepting sewer for that part of the metropolitan district south of Charles river, extensive experiments have been made during the past summer, with floats placed at six different points in the harbor. It has been very difficult to follow the course of them all, for many successive days, as they became rapidly dispersed, and were often driven by wind and storm. A chart has been prepared, giving the courses of all these floats; but the multiplicity of lines would only confuse the reader, and therefore only the general results are given. They may be concisely stated as follows:

Starting from Commercial Point, City Point, and Charles river, below West Boston bridge, sewage would be deposited in large quantities even if discharged on the ebb tide, as it would return in considerable quantity by the next flood.

Starting from Castle island or Moon island, sewage discharged on the flood would be deposited, to a considerable degree, on the flats of the Charles and Mystic rivers, or on Dorchester and Quincy bay flats. Discharged at and immediately after high tide, it would generally go as far as Bell Buoy or Boston Light, with a certainty of not being a source of nuisance by the returning tide.

Of the two points just mentioned, Castle island is objectionable, for three reasons:

1st. It is not remote enough from what will be soon a densely populated part of the city.

2d. The discharge of such a mass of sewage into such a thoroughfare as the main ship-channel should be avoided, provided another available point could be chosen.

3d. It can hardly be expected that sufficient land could be obtained from the United States government for the erection of the necessary works on Castle island. if, indeed, permission could be got to use the island at all. In South Boston sufficient land for a reservoir and pumps would be got only at great cost.

If the sewage were discharged into the channel of Dorchester bay, probably no offense would arise for some years; but the time would almost certainly come when the accumulation of organic matter would become so great as to render complaints quite frequent; for much of the sewage would pass backward and forward without getting farther than Spectacle island; and no inconsiderable quantity would be likely to deposit on the flats.

For the cities lying north of Charles river the problem is more simple. The experience of the English cities Weymouth and Hastings leads us to conclude that sewage cannot be discharged on an ocean-beach without its being the source of a nuisance. With us the only available point where sewage would be carried from the northern outlet out to sea, by a rapid current, is Shirley gut.

THE INTERCEPTING SYSTEM.

The plan recommended is to discharge all the sewage from that part of Boston situated between the Charles and Neponset rivers at the north end of Moon island.

The main intercepting sewer is to be located in nearly a direct line from Cottage Farm station to the Neponset river, near Savin hill,to cross this river by a siphon, and thence to be built along Squantum point to the end of Moon island.

The general course of this sewer will be understood from the following list of streets through which it is to pass, viz: Beacon street from Cottage Farm station to St. Mary street; thence to the junction of Tremont and Cunard streets; thence in Windsor, Madison, Hunneman, and Yeoman streets and Norfolk avenue and Clapp and Mt. Vernon streets to Dorchester avenue; thence in nearly a direct line to Neponset river north of Savin hill. The sewage is here to be raised by pumping, and passes by a siphon under Neponset river into the main outlet-sewer.

The grade of the sewer at Cottage Farm station is to be one foot below low tide. The fall, or inclination, is to be one in twenty-five hundred, or twenty-five inches per mile. The sewer is to be circular, nine feet in diameter from Cottage Farm station to Albany street; nine feet by eleven (equal to a circle ten feet in diameter) thence to the pumping station; thence to the outlet at Moon island, at first ten feet by twelve (equal to a circle of eleven feet in diameter), and finally twelve feet by thirteen; thus enlarging the storage capacity of the outfall sewer.

The siphon under Neponset river is to be six feet in diameter and fifteen hundred feet long. It is designed to be of wrought iron, properly protected from the action of salt water. Chambers are to be built at each end of it for connecting a second siphon. The results of further surveys and borings at this point may show that it world make a more permanent and less expensive structure to build a brick tunnel laid in Portland cement with iron ribs to strengthen the masonry.

There is to be built at the outlet on Moon island a reservoir to hold twenty-five million gallons, which is somewhat more than the usual amount of sewage now discharged in twenty-four hours. The discharge into the sea is to take place at each tide for the first two or three hours after high water.

It is proposed to erect at the pumping-station three engines, of 145 horse-power each. This is a very liberal provision for the present; but, in view of the free use of water after the completion of the Sudbury aqueduct, it is thought best to make it. The lift will be from twenty to thirty-three feet. The grade of the outfall sewer is at this point fourteen feet, and at the outlet eight feet above low water.

The sewer from Cottage Farm station to the Neponset river is to drain all that part of the city which lies between it and the Charles river and the harbor on the north; also all that part of the city south of it and at the same time below grade forty. It will be large enough to drain twenty square miles, and to take the sewage from a population of 750,000. Its capacity is three hundred and forty-five cubic feet per second, or over two hundred and twenty million gallons per day.

The size of the outfall sewer is sufficient to carry the sewage from a population of one million, and also one-fourth of an inch rain-fall per day from an area of thirty square miles. Its capacity is four hundred and forty-five cubic feet per second, or over two hundred and eighty million gallons per day.

In determining the sizes of the sewers, we have assumed the amount of sewage to be seventy-five gallons per day per inhabitant; but, as the *maximum* flow would be at the same rate as if this were all to be discharged in *twelve* hours, we have fixed the sizes large enough to discharge double that amount, and, in addition to the above, an amount of storm water at the time of the maximum flow of the sewage equal to one-fourth of an inch of rain-fall per twenty-four hours. The large capacity of the sewers fixed upon will be sufficient to carry off or impound for the time a still greater rain-fall per hour. It should, however, be here stated that this plan contemplates the construction of storm-overflows at suitable points, so as to prevent in times of very great or long continued rains a surcharging of the sewers.

It is also to be understood that the natural water-courses in Dorchester, Roxbury, Brookline and Brighton, particularly Stony brook and Muddy brook, are to be kept open, and free and clear from sewage contamination, and that their channels are to be straightened and to discharge as at present into the Charles river; for no sewers could be built at reasonable cost large enough to carry off these waters in case of storms. If by the growth of the city it should ever become necessary to cover them or other natural water-courses, great care should be taken that their character as drains for the soil be maintained without allowing any ordinary sewage to be discharged into them, but only occasionally an excess of storm-water.

The sewage from those portions of the city situated south of the main intercepting sewer, and above the plane of forty feet above low water, can be intercepted by a high-level sewer and delivered into the outfall sewer without pumping. The district is not now so densely populated as to require this; and for the next ten or fifteen years the sewage from such portions as require sewers can be delivered into the low-level sewer and pumped.

The principal branch of the main sewer is to be located in Albany street, from Yeoman street to Kneeland street, and at this point to receive a lateral to be built in Kneeland, Federal and Broad streets, and Atlantic avenue to Central wharf; from the junction of Albany and Kneeland streets it is to be built in Kneeland Elliot and Pleasant to Boylston, and thence to junction of Arlington and Marlborongh streets and in Marlborough to Parker street. At the junction of Marlborough and Arlington streets it is to receive a branch to be located in Arlington, Beacon, Brimmer, Pickney and Charles streets to Leverett street.

The location of this branch intercepting sewer on Marlborough street is recommended on account of economy in construction, and the saving of much annoyance to the public by obstructing Beacon street for so long a time as would be necessary, to say nothing of the danger of accidents to the water-mains there.

The desirableness, however, of keeping the tide more perfectly out of this district, the ground-water of which fluctuates in consequence of it from one to three feet at every tide, and any future examinations and negotiations which may be made with the owners of the property on the north side of the mill-dam, may satisfy the city that it would be better to rebuild the sea-wall there, making it water-tight, and then construct the sewer inside of it.

It is recommended to close that portion of the Roxbury canal west of Albany street. If this is done, the expense of a siphon for the sewer in Albany street will be saved; and the value of the land reclaimed will more than compensate for the expense of filling it, beside greatly improving the sanitary condition of this immediate vicinity.

The sewage from South Boston is to be intercepted by a sewer to be built in Dorchester avenue, A street, and First street to Second street. It is thought that for the present it will not be necessary to build this sewer farther than from its junction with the main in Dorchester avenue to B street, where it will intercept a large sewer, which now discharges into South bay.

The sizes of the branch intercepting sewers will vary from four feet in diameter up to seven and one-half feet; their minimum inclinations are to be one in two thousand, or thirty-two inches per mile.

The inclination of all the sewers is to be sufficient to give a minimum velocity of about two miles per hour, and thus prevent any deposit of sediment in them.

It will be perceived by an examination of the most recent experience in connection with the sewers of European cities that more and more attention is paid to flushing them, notwithstanding they may have sufficient grades to be what is called self-cleansing. The advantages of this will be perceived when it is remembered that, in continued dry weather, the effective scour of a small amount of sewage may be considerably less than the average estimated for, and yet even the maximum must be provided for in the sizes of the sewers. With such experience before us, we would take advantage of the excellent facilities that exist for flushing purposes at high water, along the Charles river and other tidal fronts of the city, and from any tidal basin that may be constructed in the proposed park near the mouths of Stony and Muddy brooks.

We propose that the main and branch intercepting sewers shall be so constructed that no water will leak into them through their bottoms or side walls; for by just the quantity that may be thus allowed to leak into them will their efficiency be diminished. We also propose so to graduate the inlets of the lateral sewers into the main and branch intercepting sewers, that no more than the sewage proper and the due proportion of storm-water shall be allowed to enter; otherwise the storm-water would interfere with the proper action of the main and outfall sewers. The details for effecting this, though simple in themselves, are, like others, necessarily omitted from this general report. The length of the main intercepting sewer and branches for the south side is fourteen and one-fifth miles.

The total estimated cost of the sewers herein recommended for the south side of the Charles river, including an allowance of three hundred thousand dollars for rebuilding old sewers and connecting them with the intercepting sewers, is $3.746,500, of which the details are as follows:

Main Sewer and Branches to the Pumping-Station	$1,483,182
Engines and Pumping Station	300,000
Main Outfall Sewer	875,000
Reservoir	350,000
Land Damages	125.000
	$3,133,182
Engineering and Superintendence, etc., 10 per ct.	313,318
	$3,446,500
Rebuilding and connecting old sewers	300,000
Total	$3,746,500

The main intercepting sewer for the district north of the Charles river is to commence in Cambridge at the north end of the approach to the Brookline bridge; its general course is through Waverly street to the Boston and Albany Branch Railroad; thence along the northerly side of the railroad, crossing Main street into Portland street, and in Portland, Medford, Poplar and Redmond streets to Charlestown; thence in Cambridge and Alford streets to the Mystic river, crossing it by a siphon south of the Malden bridge to Bow street; thence across the marsh to Locust street south of the Eastern Railroad; thence through Chelsea parallel to the railroad to Chester street, and in Chester street to Marginal street; thence crossing Chelsea creek by a siphon to Breed's island; and across this island along the northerly foot of Breed's hill; and finally by a siphon across the inlet to Winthrop, and thence crossing Beach street near Main street, and passing west of Winthrop Head to the outlet at Point Shirley.

The grade of this sewer at the junction of Brookline and Waverly streets is to be two feet above low tide. The fall per mile is to be twenty-five inches. It is to be four and one-half feet in diameter to Main street, six feet in diameter to Cambridge street, and seven feet in diameter to the junction of Cambridge and Canal streets in Charleston, where it receives the lateral sewer from that district. From this point to the west end of Breed's island, where the pumping-works are to be located, it is to be eight feet in diameter. The branch from East Boston is to join the main sewer at this point. From the pumping-works to the outfall ot Point Shirley, the main sewer is to be nine feet in diameter. The capacity of this main outfall sewer is two hundred and sixty-one cubic feet per second, or about one hundred and sixty-nine million gallons per day.

The principal lateral is to commence at the junction of Main and Third streets in Cambridge, and to pass through Third, Spring, First, Cambridge, Bridge and Prison Point streets to the month of Miller's river, crossing it by a siphon to Charleston, and thence through First and Canal streets to the junction with the main line in Cambridge street.

This sewer is to be four and one-half feet in diameter from Main street to Charleston, and thence to its junction with the main intercepting sewer five feet in diameter.

If the streets in East Cambridge should be filled out to the Commissioner's line, it would be better to build this sewer in Prison Point street, and in First street to the West Boston bridge.

For draining East Boston it is proposed to construct a branch intercepting sewer parallel with and east of the Eastern Railroad, thence along Reynolds street to the creek, thence across Breed's island and around the west-

erly end of Breed,s hill to the main north outfall sewer.

This sewer from Maverick street to Neptune street is to be four and one-half feet in diameter, and thence to the junction with the main sewer on Breed's island five feet in diameter. For temporary purposes until the system of main intercepting sewers shall be built and in operation, Mr. Bradley's plan, which he has already commenced carrying out, is recommended; that is, to collect the sewage of the easterly side or slope into one sewer and discharge it into deep water at the southwesterly end of the island. The outlets of the other East Boston sewers do not cause any serious complaint at present.

It is proposed to erect at the pumping-station on Breed's island two engines of 145 horse-power each. The lift will be from twenty-three to thirty feet. The grade of the outfall sewer is at this point seventeen and one-half feet above low water.

There is to be at the outlet near Point Shirley a reservoir to hold twenty million gallons, from which the discharge is to take place twice each day for the first two or three hours after high water.

The length of the main sewer and branches for the district north of Charles river is fifteen miles. The estimated cost, including reservoir and pumping-station, and an allowance of one hundred thousand dollars for rebuilding and connecting old sewers with the intercepting sewers, is $2,804,564; of which the details are as follows:

Main Sewer form Brookline bridge to Point Shirly 10.69 miles	$1,538,395
Branch Sewers 4.31 miles	270,300
Engines and Pumping-Station	200,000
Reservoir	300,000
	$2,308,695
Land Damages	150,000
	$2,458,695
Engineering and Superintendence 10 per cent	245,869
	$2,704,564
Add for rebuilding old sewers, etc	100,000
Total	$2,804,564

CONCLUSION.

It would not be practicable to enlarge the outfall sewers in case future need should demand increase in that direction.

Therefore a very considerable outlay must be made now to avoid such necessity; but it is not advisable to make the reservoirs much larger than the present population requires. Thus not only an important amount of interest may be saved, but considerable and valuable experience gained in the mean time both as to the necessity of future enlargements and the possible utilization of some of the sewage. We would, however, recommend the securing at once of all the land ever likely to be needed for reservoirs.

The surveys upon which this report is based were made under the direction of Mr. Wm. H. Bradley, C. E., Superintendent of Sewers, by Col. C. W. Folsom, C. E. We take pleasure here in acknowledging the courteous manner in which Mr. Bradley furnished all the information we asked, and the valuable suggestions made by him, which his long familiarity and experience with the peculiarities of Boston sewerage enabled him to do.

Among the many advantages of the general plan here recommended, viz., pumping the sewage and discharging the same at high tide, may be mentioned the following:

1st. The sewage is removed entirely from the limits of tne city and discharged so as to be carried out to sea, whence it will not return. Our experiments convince us that this can be done certainly on the ebb tide.

2d. *There is a constant and uninterrupted flow of the sewage from the time it enters the sewers until it reaches the outfall sewer. All sewage is thus removed before it becomes offensive, and there is no deposit in the bottom of the sewers.*

3d. In a system of sewers of this design skilfully constructed, the level of the ground water will be kept several feet lower than it is now. This point is one of great importance in view of the direct connection, as shown by Dr. Bowditch and Dr. Buchanan, between soil-moisture and pulmonary consumption, a disease which causes about one-sixth of the total number of deaths in Boston.

4th. It will be practicable to rebuild such sewers as have been extended from time to time on newly made ground, which consequently have little or no grade, sometimes with inclinations the wrong way, and which it is now very difficult, if not impossible to keep clean.

No system of sewerage and no degree of perfection in the sewers themselves can be expected to render our dwellings free from bad smells or danger to health unless the house-drains, soil-pipes, etc., be also carefully attended to.

We therefore recommend

1st. That soil-pipes be carried through the roofs to a point two feet above them, and not near chimneys or windows; and that they have on their tops some approved automatic ventilator, one of the best of which is Capt. Liernur's modification of Saint Martin's, originally proposed to the French Academy in 1778. Ventilating pipes may pass into chimneys if the latter are always kept hot.

2d. That rain-water spouts be untapped and discharge into the sewers, *provided that their upper ends be remote from windows or the tops of chimneys communicating with rooms occupied by human beings.*

3d. That house-drains be made free from the faults mentioned on a previous page.

4th. That there be inspectors appointed, whose sole business it shall be to see that house-drains are properly constructed and kept in order.

5th. That no new houses be occupied until they have been properly inspected, and their drains have been found satisfactory,

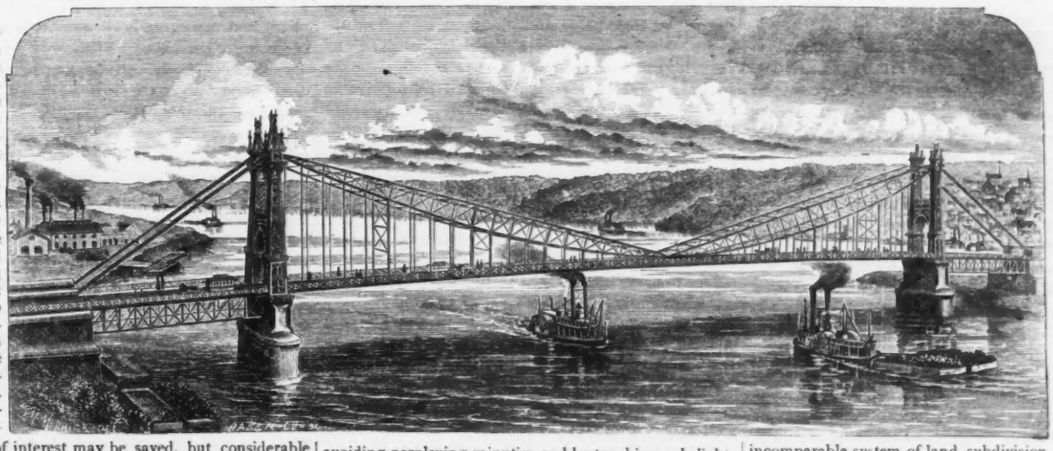
6th. That an intercepting sewer, with branches and pumping-stations, be constructed according to the plans already given, the necessary modifications of the old sewers to be determined as the work proceeds.

7th. That the means recommended for flushing be freely used and the sewers be kept as clean as possible.

8th. That the new sewers, and also many of the older ones, as they become clean, be ventilated by free openings, the positions of which are to be regulated by experience.

Finally, we have omitted many details, and we have avoided mention of any subjects which may perhaps be thought deserving of discussion; but we have been anxious to confine our report within reasonable limits, by avoiding perplexing minutiæ, and by touching only lightly upon matters of sanitary interest, which we have not space to discuss in full. Respectfully submitted,

E. S. CHESBROUGH.
MOSES LANE.
CHAS. F. FOLSOM.



Point Bridge.

We present herewith an illustration of the suspension bridge crossing the mouth of the Monongahela river, at Pittsburgh, Pa., now in process of construction by the American Bridge Company of this city. The bridge is suspended on stiffened chains, a method as yet, so far as we know, new in American Engineering practice. The length of the main span is 800 feet, and the height from the bed of the river to the top of the iron suspension towers is 210 feet. We hope to be able to publish the details of this important structure at some future time.

CORRESPONDENCE.

PRACTICAL QUESTION IN HYDRAULICS.

In a stand pipe 5 feet in diameter, water enters constantly through an inlet pipe at the rate of 1,500,000 U. S. gallons in 24 hours. There is also a constant discharge from the bottom of the stand pipe, that will deliver at the rate of 1,000,000 U.S. gallons in 24 hours, when the head in the stand pipe reaches 50 feet. Required the size of a discharge pipe placed 10 feet from the bottom of stand pipe — length of discharge pipe being 8 feet, at the end of which is placed a quarter circle bend, 2 feet radius, discharging downward — that will allow the water in the stand pipe to rise only to a height of 50 feet, and also the time required for the water to reach that height, — advantage being taken of the most approved form of mouthpiece of discharge pipe where it enters stand pipe. G. M. A., *Henderson, K'y.*

THE METRIC SYSTEM.

NASHVILLE, ILL., Feb. 15, 1876.

EDITOR ENGINEERING NEWS: — I have been wondering for some time past if some engineer or surveyor would not speak out on the subject of the "Metric" system, and I feel gratified that the subject has, at last, got into the proper hands, and more especially that the people of the West have finally begun to think about it. In the countries across the water, and in the eastern portion of the United States, a transition from the old to the new measures will be simple enough, and there, all will soon be ready for it. But how is it going to be in the great West, where all the land is laid out and sold by the *square mile* and subdivisions thereof down to the acre; where most of the improved land has been surveyed again and again, and has a long history in records under the old system?

The engineers' chain in France and other countries using the metric system is ten metres in length, with links equal to one decimetre. Of such chains there are 160.9347 to one mile, or one side of the old section. Now, the inconvenience of this in subdividing land is apparent at once to the land surveyor who lives, as I do, where the land is all laid out and permanently improved by the old system. While I admire the new system, and trust that it may prevail, I fear that it will be utterly impossible to adapt it to "sectionized" land. The merits of the French system are two and *two only*, the most important of which is that it is decimal; the second is that it is likely to become international. In the first of these qualities it can claim nothing over our Gunter's chain; as to the second, land measure can never become international.

Though we may much admire the metric system for other purposes, will we not have to retain our preseut incomparable system of land subdivision, with its base the Gunter's chain? If we wish to discard the old inch and foot and deduce everything from the metre, we have but to take 20.12 m. and divide in one hundred parts, and we have our old chain, or, at least, one which will measure the old mile within .29 of one inch.

I would like to hear from other land surveyors on this subject. Architects, mechanical engineers, and even land surveyors who work where the land has not been originally sectionized, can have but little conception of the magnitude of this subject to the western land surveyor. M. L. McC. *Surveyor.*

"CREEPING RAILS."

INDIANAPOLIS, IND., Feb. 21, 1876.

EDITOR ENGINEERING NEWS: — In the article taken from the *Scientific American* on "Creeping Rails," is there not another error in addition to the one answered by L. H. Clarke. The author of that paragraph holds that on account of the motion of the earth "the western rail, being relieved of its share of weight 'creeps' more freely and quickly." If the motion of the earth had any perceptible effect, would it not cause the train to press more heavily upon the western rail than upon the eastern? Also, do not the rails of the roads doing the heaviest business "creep" the most? J. A. H.

The prospect for a narrow-guage railroad from Toledo, O., to South Haven, Mich, is considered to be excellent.

It is reported that the government of Egypt has adopted the Gregorian instead of the Mohammedan calendar, and that public business was done at New Year's upon the European system.

ENGINEERING NEWS.

SATURDAY, FEBRUARY 26th, 1876.

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SANITARY ARRANGEMENT OF DWELLINGS.

In towns and cities unprovided with sewers, and in the unsewered portions of cities, the refuse matter of the kitchen is conveyed to receptacles known as *cess-pools*. If these are placed at a sufficient distance from the house, and properly constructed and ventilated, and are emptied of their contents sufficiently often, there may no evil consequences arise from their use. They are, however, to be avoided if possible, as, the surrounding soil once saturated with the matter from them, is very slow in purifying itself, and at some future day may bring disease and death into an unsuspecting household.

A few years ago a pestilence broke out in a South American city, which in a very short time carried off thousands of the inhabitants. It appeared that there was not only no system of sewerage, but that the refuse of the houses and the excretions of their occupants, were deposited in cesspools beneath and adjoining the dwellings, and this had continued for years, until the soil had become one mass of putrescence, giving forth constantly a deadly gas which at last awakened the people to their danger by bringing desolation to a thousand homes. We thought, as we read of this ignorant neglect of the simplest sanitary arrangements for the health of the people, that it was not possible for a highly civilized community to fall into the same guilty error. But the accounts of some of the small villages and towns of England, given in engineering reports show an equally wretched state of affairs in some parts of that enlightened country, so full of wealth, culture and Engineers.

In an English work entitled "Sanitary Arrangements for Dwellings," we find an example quoted.

"In 1870, a house in Wimpole street, London, was discovered to be in a very offensive condition, and, on opening up the basement, a chain of five cesspools was exposed, each about six feet in diameter and twelve feet in depth, connected togethef by a brick drain. The oldest pit lay nearest to the main sinks, etc.; and it would appear that when one was full another was dug, and so on until the atmosphere of the house proved unbearable. There was no connection with any sewer, and the liquid wastes simply disappeared in the gravel. Next door, four similar cesspools were laid bare; and, in addition to these, a hole fourteen feet square and eight feet deep, full of putrid water, and its silt, was discovered exactly in the middle of the kitchen. Likely enough this hole had been made for the use of the workmen who built the house originally, or it might possibly have been the ancient idea of a rain-water tank. Unlike the cesspools, it was deep enough to reach the clay, which between High Street and the bottom of Portland Place is close to the surface."

The author then gives several examples of imperfect drainage and the use of cesspools in country houses. In one case the fall of the drain was so slight that for *30 years the solid portions of the sewage and other wastes had never reached the sewer*, but remained in the brick barrel drain. After reading a few of these examples we can realize how necessary it is that before the Prince of Wales again accepts the hospitality of any of the "fine old homes of England," a careful investigation into its sanitary arrangements be made by a competent engineering commission.

But there is no necessity for Americans going beyond the limits of their own homes to learn the dangers of defective drainage and sewerage and the use of cesspools. We havs no personal acquaintance with these matters as they exist in other cities of the Union, but in the pursuit of our regular duties as a surveyor in this city we could not but meet with frequent instances. With one case, however, we are especially familiar. A few days after the great fire of October 1871, in common with the rest of the burnt-out portion of the community of Chicago, we were searching for another place of business. This we found at No. — Wabash avenue, in the basement study of a worthy Presbyterian clergyman, who for the modest sum of $400 per year gave up to us the use of his little 10 x 12 room. Some time afterwards we rented for the use of a printing office the balance of the basement, and still later, the rear portion of the upper part of the building. The front part was let to other tenants until the whole house (which was worth perhaps $3000) was let for the sum of $4300 per year. The parson moved out, and the printer's family moved in, but after a month or so was driven out by the bad air of the house. We then occupied the kitchen and dining room above the basement as an office, but after the most thorough overhauling of sinks and pipes and everything else that we could get at, and after three visits from the health officers, in consequence of complaints lodged with them, we had to make up our mind to endure the place and trust to carbolic acid and our good constitution to carry us through. Our draughtsmen were soon "laid out," however, and could not put in more than three-fourths time, and at last when the wife of a sub-tenant, who occupied the rear basement kitchen, was carried out in a fainting condition from her room, we thought that it was time to know where the trouble came from. The parson was interviewed, and somewhat reluctantly admitted that beneath the *kitchen floor* was a receptacle for the sewage from the house. The health officers investigated and found a cesspool six feet deep and *full to the very floor*, over which our worthy landlord and his family had been living for years. A thorough cleaning out and disinfecting did not succeed in removing all the effluvia, and we were only too glad when the rebuilding of the business portion of the city gave us an opportunity of getting back to healthier quarters.

That basement cesspool is only one of hundreds that exist unsuspected in this city, and in other American cities, and an occasional sweeping conflagration which may inconvenience a few people for a time, and perhaps obliterate a few rotten Insurance Companies, yet sometimes acts as a purifier of localities which no other disinfectant could reach, and in making a chance for better sanitary arrangements in the rebuilt dwellings, stays more or less the progress of disease and death, and so affords a compensation for losses that have not entered into the "Adjuster's" reckoning.

This matter of cesspools is a part of the house drainage and is very largely subject to the decision of the architects. It is for them to see that proper sanitary arrangements in dwellings under their charge are planned and carried out, otherwise they are responsible for the evils resulting therefrom.

The Convention of General Railroad Ticket Agents, at Louisville, has agreed upon a reduction of twenty-five per cent. in railroad fares, each way, during the Centennial season.

The huge bullion scales in the Carson, Nevada, mint are so delicately adjusted, that the difference in weight between a grey and a brown hair from the same person's head can be readily determined, a recent test showing the difference to be two-millionths of a grain.

It is understood the Directors of the Wheeling and Lake Erie railroad have decided to change the terminus of the route from Norwalk or Sandusky to Fairport, as a connection with the Painesville and Youngstown Narrow guage is contemplated.

We commend to the attention of our readers of the communication from Henry S. Drinker, M. E., on the subject of a Treatise on American Tunnelling. Mr. Drinker was for three years the Resident Engineer in charge of the construction of the L. V. R. R. Extension of the Musconetcong Tunnel, a description of which has been published in *The Engineering and Mining Journal*, and reprinted in part in ENGINEERING NEWS; he has been engaged for a year past in collecting data for his book, and it is fair to presume that the work when completed will be not only a very valuable contribution to American Engineering literature, but must also take first rank as a reliable and full text-book on the hitherto neglected subject of Tunnelling, for the use of our technical schools of Engineering. We feel sure that Engineers throughout the country will respond with pleasure to the request for information by Mr. Drinker, and so assist in the preparation of this really valuable work.

IMPROVEMENT IN SURVEYOR'S CHAINS.

To a careful surveyor, the keeping of a *correct* chain is a matter of first importance. It is not a creditable feature in the ordinary practice of land surveying, that exactly similar measurements are seldom obtainable by different surveyors, or even by the same surveyor at different times. While much of this disagreement in results must be placed to careless work, yet a considerable proportion is due to the varying lengths of the ordinary chain. The heavy iron Gunter is varying constantly, and is corrected by taking out, or placing in, rings between the links, while the lighter steel chains are corrected at the handles. In both cases the method is wrong, as the correction, instead of being distributed over the whole chain, is confined to two, or perhaps half a dozen places, and consequently all measurements of fractions of the whole chain must contain more or less of error. To overcome this difficulty in keeping each of the ten divisions into which the chain is divided, correct, a very simple and effective device has recently been patented by a surveyor of this city. This consists of an *adjustible link* which is inserted in each of the ten divisions, and which enables the surveyor, by means of a little wrench, which he can carry in his vest pocket, or attach to a key-ring, to correct each or every part of his chain without delay. Every chain should be fitted with the *adjustible link*, and old chains that are thrown aside for incorrectness, by the use of this simple attachment, may be made as correct as new.

Gas Items.

From the *Engineering and Mining Journal* of Feb 19, we clip the following:

In consequence of the high price of gas in Camden, $3.60 per 1,000 feet, many persons are dispensing with its use, and some are illuminating their houses with gasoline. There has been talk that the company is going to reduce the price, but no definite knowledge can be obtained as to the truthfulness of the rumor.

It is stated that the Boston Gas-Light Company will reduce the price of gas on the 1st of April to $2.25 per 1,000 feet. The price in Boston previous to 1844 was $5; from that time it was gradually reduced until it reached $2.25 in 1860; during the war it rose by successive advances from $2.50 in January, 1864, to $3.25 in January 1865; in January, 1870, it was reduced to $3, and since that time there have been three reductions.

The Cumberland, Md., Gas Co. has reduced the price of gas from $3.50 to $3 per 1,000 feet.

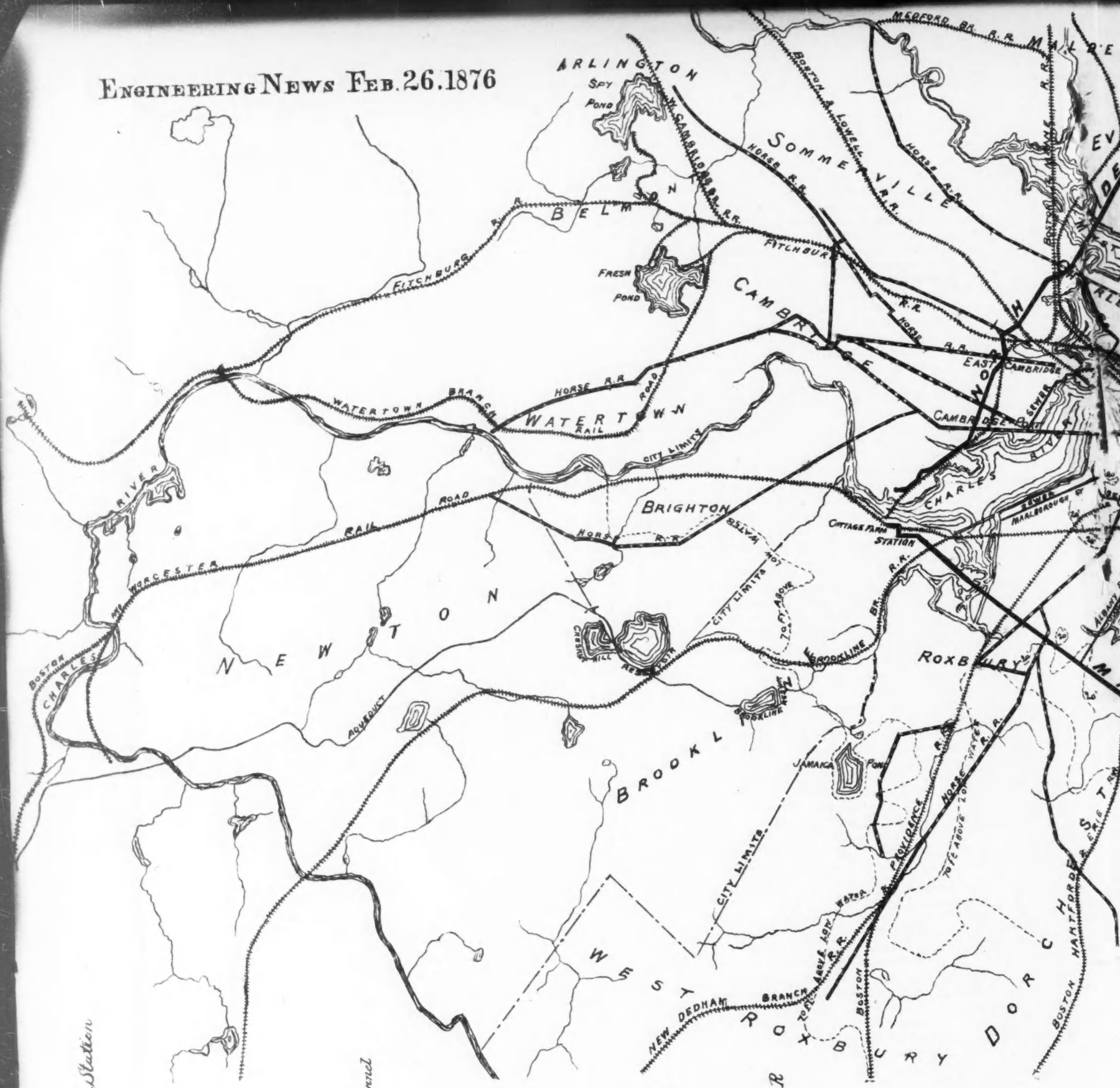
A resolution has been introduced into the New York Legislature calling on the New York gas companies for a financial report, showing a true statement of their business, embracing their incomes, dividends, and investments.

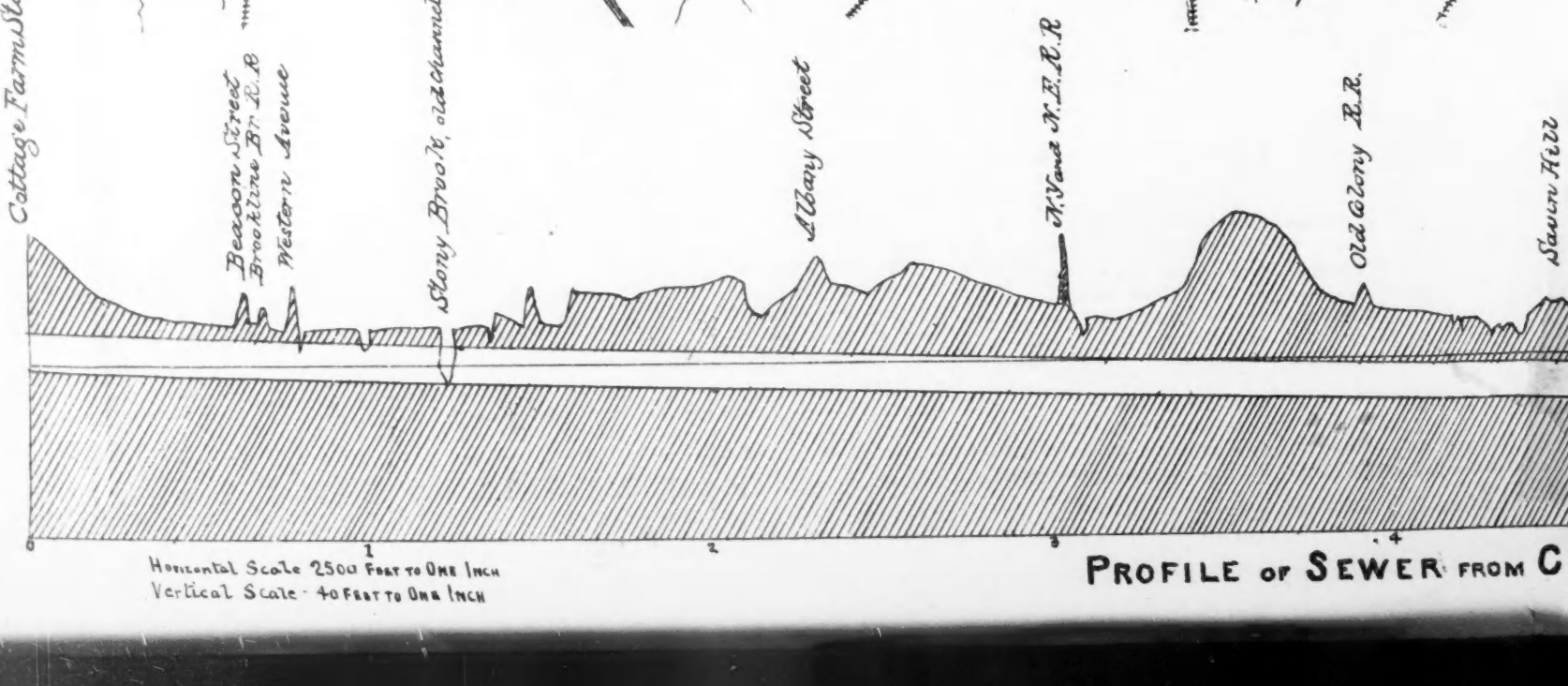
We see it stated that kerosene will be substituted for gas in lighting the streets of Lynn, Mass.

The Gas Company of Geneva, N. Y. intends manufacturing gas from wood and petroleun instead of coal. It is asserted that the gas thus produced gives as pure and brilliant a light as coal gas, and can be made and supplied to customers at greatly reduced rates, which we question.

For the year endjng February 16, 1876, Decatur, Ill., paid for street improvements $7,715, and for extension of water works, $17,704.

ENGINEERING NEWS FEB. 26. 1876





Horizontal Scale 2500 Feet to One Inch
Vertical Scale - 40 Feet to One Inch

PROFILE OF SEWER FROM C

BOSTON MAIN DRAINAGE.

PLAN

Shewing Main and Branch Intercepting Sewers recommended by the Sewerage Commission

1875

Scale. One Mile to an Inch

E. S. Chesbrough
Moses Lane
Chas. F. Folsom
Commissioners

COTTAGE FARM STATION TO MOON ISLAND

HEAT AND COMBUSTION.

A Paper read before the 'Railway Polytechnic Society, Cleveland, Ohio, Sept. 6th, 1875.

BY P. H. DUDLEY, C. E.

[CONTINUED]

We need to give close attention while we attempt to explain that it is of little matter how we burn our fuels; if the combustion is perfect the value is the same, but the calorific intensity varies. A mile is just so far, no matter whether we walk, go in a carriage, or ride in the cars, but the intensity of our motion depends upon the manner in which we go. It may take twenty, five or two minutes, yet the distance is the same in either case, though the intensity of the motion of the last was ten times that of the first. So it is with combustion of fuels, the value remains the same whether burnt slowly or fast, but the intensity of the heat depends upon the activity of the combination of the elements, the kind and quality of their products, and the amount of unconsumed air in the furnace; for the heat developed will be distributed through the entire mass.

It is usual to calculate the calorific intensity of fuels instead of making determinations by direct experiment. If the latter were pursued, although quite a difficult task, it would doubtless show us many places where loss now occurs. One pound of carbon combines with 2.67 lbs. of oxygen, producing 3.67 pounds of carbonic acid. We have before seen that the thermal or heat units of 1 lb., of carbon are 8080; therefore, if the specific heat of carbonic acid were the same as water, 8080 divided by 3.67 would give us the temperature of carbonic acid if formed in pure oxygen; but the specific heat of carbonic acid is only 0.216.

$$\frac{8080}{3.67 \times 0.216} = 10{,}065 \text{ degrees,}$$

its calorific intensity when forming in pure oxygen. In none of our industrial operations do we get pure oxygen, but we draw it from the air where it is diluted by four parts of nitrogen. This nitrogen does not contribute anything, but takes from the heat of the other combustibles a sufficient quantity to raise its temperature in common with the other products. From this it will be seen that when the carbon is burnt in the air, the intensity must be lessened by the amount of heat required to raise the nitrogen up to that of the elements which do furnish any heat. The fact is, the temperature of the others is lowered in raising the nitrogen, and we should so arrange our grates as to only admit the air required for combustion, not permitting an excess to come in contact with the fuel. 2.67 lbs. of oxygen are taken from the air by 1 lb. of carbon. In air, to each lb. of oxygen we have 3.34 lbs. of nitrogen, the 2.67 lbs. of oxygen to burn carbon in the air are combined with 8.93 lbs. of nitrogen, so that the heat will be distributed over 3.67 lbs. of carbonic acid and 8.93 lbs. of nitrogen. Multiplying each by its specific heat we have $3.67 \times 0.216 + 8.93 \times 0.244 = 2.972$, representing the quantity of heat required to raise the products of combustion 1 degree in temperature; therefore, dividing 8080 by 2.972 gives us the calorific intensity of one pound of carbon burnt in the air = 2718 degrees centigrade, only 0.295 of that obtained by burning it in pure oxygen. In calculating from its calorific value the calorific intensity of hydrogen burning in oxygen, we must now take into consideration that the water formed by the union of the hydrogen and oxygen is converted into steam, and, therefore, absorbs its full complement of latent heat at atmospheric pressure. One pound of hydrogen combines with 8 lbs. of oxygen, evolving 34462 units of heat, producing 9 lbs. of water or steam, and, if burnt in the air, leaving 26.768 lbs. of unconsumed nitrogen. In converting water into steam 537 centigrade thermal units of heat are absorbed in doing internal work, which is insensible to the thermometer, as it is taken up by the steam. The 9 lbs. of water, or more properly steam, produced by the combustion of the 1 lb of hydrogen will absorb or render latent nine times 537. or 4833 units of heat, which must be deducted from 34462, leaving 29629 available units of heat to raise the temperature of 9 lbs. of steam and 26.768 lbs. of nitrogen. As we stated in our list of specific heat, that of steam is 0.480, which multipied by 9 equals the amount of heat required to raise the temperature of the steam one degree, or in this case 4.32 units. The 26.768 lbs. of nitrogen multiplied by 0.244, its specific heat give 6.53 units, which are required to raise the nitrogen 1 degree. Dividing the 29629 units which we found above by the joint quantities 4.32 + 6.53 or 10.85, we have the number 2730 degrees as the calorific intensity of hydrogen burning in the air. We are ready, after this long explanation, to take up our formula for calculating the calorific intensity of a fuel carbon hydrogen and oxygen.

The **O** divided by 8 equals weight of hydrogen required to convert the oxygen into water, therefore, $\mathbf{H} - \frac{\mathbf{O}}{8}$ represents the hydrogen which is left available for heat. Our formula for calorific value was $8080\,\mathbf{C} + 34462\,\mathbf{H} - 4307\,\mathbf{O}$. Therefore, since oxygen combines with ⅛ its weight of hydrogen to form water, $8\,\mathbf{H} - \mathbf{O}$ = weight of oxygen required for combustion of the hydrogen in the fuel: also, as stated above,

$2.67\,\mathbf{C}$ = weight of oxygen required for combustion of the carbon in the fuel. This oxygen being derived from the air in whlch is present 3.34 lbs. of nitrogen for each lb. of oxygen, we shall have

$$3.34\,(2.67\mathbf{C} + 8\mathbf{H} - \mathbf{O}) \quad \text{or}$$

$$8.94\,\mathbf{C} + 26.784\,\mathbf{H} - 3.34\,\mathbf{O} = \text{total nitrogen.}$$

Multiplying this by the specific heat of nitrogen, 0.244 we have

$2.18\,\mathbf{C} + 6.53\,\mathbf{H} - 0.82\,\mathbf{O}$ = amount of heat required to raise the nitrogen 1 degree.

We found before that $0.793\,\mathbf{C}$ was the amount of heat required to raise the carbonic acid gas 1°, and that $4.32\,\mathbf{H}$ was the heat required to raise the steam through 1 degree. Add these two values to the above expression and we have

$$(2.18 + 0.793)\,\mathbf{C} + (6.53 + 4.32)\,\mathbf{H} - 0.82\,\mathbf{O} \quad \text{or}$$

$2.97\,\mathbf{C} + 10.85\,\mathbf{H} - 0.82\,\mathbf{O}$ = heat required to raise the products of combustion 1 degree. (2.97 and 10.85 will be recognized as the results of the separate calculations above).

Therefore, the formula for calorific value, just cited, must be divided by this last expression to give us the calorific intensity. The formula complete is

$$\frac{8080\,\mathbf{C} + 34462\,\mathbf{H} - 4307\,\mathbf{O}}{2.97\,\mathbf{C} + 10.85\,\mathbf{H} - 0.82\,\mathbf{O}}$$

in which it will be noticed that the part above the line gives the calorific value, and both combined, the calorific intensity. When we fully understand our hydro-carbons more exact formulas can be given. We stated a few moments ago that the latent heat of steam was 537 degrees, so if we wish to see how many pounds of water our coals should theoretically evaporate from their chemical composition, we must add 100° as the amount of heat required to evaporate the water, to the 537° making 637° absorbed by each pound of water upon its conversion into water.

Wood, theoretically, will evaporate from 6 to 6.5 lbs. of water from zero. Bituminous coal according to quality, from 8 to 11 lbs.; coke from 9 to 12 lbs.; and anthracite from 11 to 13.5 lbs., depending upon the kind. It is a matter of some importance to know the chemical composition of our fuels, for then we can calculate their theoretical calorific value with some degree of certainty. We have calculated the values of many of the coals sold here in the city at nearly the same price, and find that there is quite a marked difference.

Knowing the calorific value of our fuels we can easily measure the efficiency of boilers as steam generators. Steam users, especially great corporations, have given this subject only a passing notice, but it is now gratifying to see an increasing interest taken by our more liberal-minded railroad men. Soon it must be self-evident that it wlll be made the exclusive duty of some one to look into details which are now unheeded. The leading idea has been to get the most physical work out of subordinates possible, and time and necessary facilities are not given to observe and study, much less master the details of their respective departments. Brain work is at a discount so far as what seems to be abstract principles. There is no one better situated than the practical man to observe and study the effects, and trace the causes so that principles can be discovered. The purely book and scientific man is generally selected to make the applications of principles which he is so well qualified to discover and investigate, but he fails in attempting to reduced them to every-day use from the fact that in practice he does not anticipate the contingencies which daily arise; thus science is made to bear the blame of unskillful manipulation, and practical men look upon it as of doubtful utility, because it does not meet their expectations, when, perhaps, the necessary conditions are not supplied.

The mechanical equivalent of heat has been determined with great accuracy by so many different processes, that it may be regarded as nearly correct, and for our thermal unit is equivalent to raising 1390 lbs. one foot high—*i. e.* the heat required to raise one pound of water one degree, according to the centigrade scale, requires the same force as that contained in 1390 lbs. falling one foot. It will not be possible to devise a machine which will return all of this power, on account of the loss by friction, and the want of proper application. Water wheels have been constructed which utilize 90 per cent. of the value of the water, but most of them fall below. The maximum effect of most does not exceed 55 to 60 per cent. Machines do not create but only transmit part of the power applied to them. It is well to know what they ought to do, if perfect, as then, by measuring the amount done, we are better able to judge of their relative economy. Men who have given the subject much attention, say that our best steam engines do not give us over ten per cent. of the value of our fuels. In locomotives it will not exceed six per cent.,—(recent experiments show it to range from 3 to 4.5 per cent.).

[When this paper was read, it contained a calculation of the value of the coal used in running a train over the Cleveland & Pittsburg Railroad, but the estimate was too high as shown by recent experiments with the Dynagraph, and as exact results will be published in future papers, the example then stated is here omitted].

By taking the amount of work done, the coal required to produce it, and the chemical composition of the latter, we can see by the formulas given, the percentage of work obtained as compared with the theoretical. I do not know of any subject of greater importance, of greater scientific and practical interest, than this one of being able to measure the actual resistance or the work done by our motors, especially in respect to transportation, where it is of the greatest importance to do as much work as possible with the least expenditure of force or money. The practical question is, can we improve upon our present methods of transportation? While I believe that a great saving can be made, I do not expect a revolution will be made at once, but the progress will be gradual. We must study the adaptation of motive power as well as its better development. There are practical matters of construction which must be taken into consideration, as well as the economy of any one distinct process. It is an adaptation of the best means under all circumstances which will give the best results. How shall we do it,—by ignoring principles and working at random, or working in accordance with them? To me, the answer to this question is plain, self-evident. Let us look into details. The power which we seek is in the coal, and by chemical combinations, by combustion, we expect to disengage it, and take advantage of the force liberated. For our purpose the steam engine is the machine with which we expect to gather up and transmit the force, therefore the amount of power obtained depends upon its perfection.

The products of perfect combustion are gases which form in accordance with unchangeable laws, and, if we analyze the products, they will show what gases were formed. We shall have 20 per cent. of carbonic acid, 79 per cent. of unconsumed nitrogen from the air, and some steam, which will all be condensed before the gas can be analyzed. We have now collected nearly 50 specimens of gas from locomotives of various railroads here in the city, and some from stationary boilers. In all cases we find an excess of air has been admitted into the fire boxes, diminishing the calorific intensity of the fire. The analysis will be treated more extensively in subsequent papers.

The required amount of air to supply the necessary oxygen to burn the coal can be calculated from its composition. For our bituminous coals it generally takes 150 cubic feet of air for each pound of coal, or 300,000 cubic feet per ton. To consume the volatile part of the coal nearly one-third of this should be admitted just above the burning coal, in small but rapid streams. Sufficient time is not given to heat up the air, nor room for the full development of the flame before being drawn into the small flues, which extinguish the flame and arrest further combnation While the priinciples are well known, it is found quite difficult to so construct furnaces that the firemen will be obliged to follow out the principles of combustion under all the various circumstances. Opin-

ions differ as to the best means to adopt, largely because theories are taken for facts. The same kind of furnaces are used to burn all kinds of coal. The heat is not all developed which the coal will yield. If the fuel was in a liquid or gaseous state its application could be more easily controlled, and so far better results have been obtained than with coal.

Now, after the heat is developed, a large portion is lost by radiation from the boiler, fire-box and steam cylinders, when the locomotive is in motion. Much of this loss could be prevented by more efficient protection to the surfaces. No one is benefitted, but it goes to make up the great aggregate of expenses. It is seemingly a small thing to save a few units of heat upon a single locomotive, but in the total number, 14,500 in the United States it becomes an important item. Allow four thousand of these out of use for repairs, give the others a daily mileage of ninety miles, and we have 10,500 multiplied by 90 —equals 945,000 miles, which must be nearly the actual daily locomotive mileage. The heat of the products of combustion, is far from being absorbed, the escaping gases having a temperature ranging from 300° to 400° centigrade. It is not necessary that they should have this temperature for draft, as that is now largely produced by the blast or exhaust steam in locomotives. A great saving can be made by utilizing some of the waste heat of the exhaust steam. The feed water could be warmed, and also the air for combustion, as the chemical activity is increased by an elevation of temperature.

I will call attention to but one more principle to-night, and that is the expansion of steam. We will assume that steam in the boiler is at 100 lbs. pressure; if we fill our cylinder with the steam at any point it will represent still 100 lbs. pressure. Let out this steam into the air, and it will have a pressure of 85 pounds above that of the atmosphere, in fact it might perform much work. We have liberated our force long before its power was fully utilized. We must recollect that the steam represents a certain definite quantity of heat units. If we cut off the steam at one-half stroke, and allow it to expand to complete the stroke, we shall increase its efficiency 1.70 times; at one-third stroke, 2.1 times; at one-fourth stroke, 3.4 times.

The proper conditions for expansion must, however, be observed. A saving of fuel is, of course, effected. In nearly all large steamships compound engines are used, so as to take advantage of the expansive power of steam. I am not aware, at the present time, that any really expansive valves are used upon locomotives; the link motion, simply wire-draws the steam, and does not produce a good expansive effect. The first locomotives built here at the Cuyahoga Works in 1852, '53 and '54, were fitted with expansive valves, but, as a saving of fuel, was then of but little object, they were discontinued.

GRAPHICAL ANALYSIS OF ROOF TRUSSES.

BY CHAS. E. GREENE, A. M., PROF. OF CIVIL ENGINEERING, UNIVERSITY OF MICHIGAN.

XI.

Having treated of the action of external forces upon a great variety of trusses, we propose now to investigate the graphical determination of the bending moments which occur on certain pieces.

To recapitulate the statements of an earlier article:

In case the transverse components of the load upon a portion of a rafter, or other piece of a truss, are not immediately resisted by the supporting power of some adjacent parts, or, in other words, unless the load on the structure is actually concentrated at the several joints, such transverse components will exert a bending action upon the portion in question, and the additional stress thus caused in the piece may be too great to be safely neglected. Further, in case the piece makes any other than a right angle with the line of action of the load, or has an oblique force acting upon it, the stress along it, given by the diagram, will be less than the maximum, and will generally be the mean stress. Lastly, in case a piece is curved, a bending moment will be exerted upon it by the force acting along the straight line joining its two ends, this bending moment being a maximum at the point where the axis or centre line of the piece is farthest removed from the line drawn between its ends.

The reader is referred for an illustration of the truth of some of the statements to Article VI, Fig. 17; but to take another, and a simple example:—

Suppose the rafters A C and B C, Fig. 22, to be loaded uniformly over their whole extent. Let us assume, in the first place, that the tie A B is not used, but that the thrust of the rafters is resisted by the walls which carry the roof. Consider the piece A C. Since the roof is symmetrically loaded, the thrust at C must be horizontal and therefore the reaction which supports this end of A C will lie in the line C E. The centre of gravity of the load on A C being at D, its middle point, the resultant of the load will, if prolonged upwards, intersect C E at E. Since the rafter is in equilibrium under the load and the reactions at C and A, the direction of the reaction of the abutment or wall at A must also pass through E, (Compare Figs. 3 and 4.) Draw A E and prolong E D to G. Let E G be measured by such a scale as to represent the load on A C. The three forces meeting in the common point E will then be equal to the respective sides of the triangle A E G, drawn parallel to them;

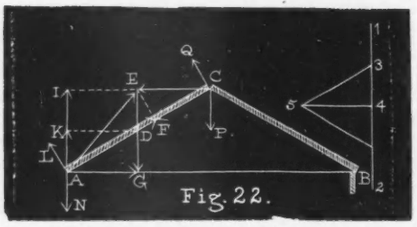


Fig. 22.

and, since A G equals E C, the reactions at A and C will be A E and C E.

Decompose A E and C E into components along and transverse to the rafter, and we shall have A F = direct compression on the rafter at A, while C F = direct compression at C. The compression on successive sections of the rafter increases from C to A by the successive longitudinal components of the load. The two components A L and C Q, which, combined with A F and C F, give the original forces A E and C E, are analogous to the supporting forces of a beam or truss, and from them we obtain the amount of the bending action of the load on this rafter.

If, now the rafters simply rest on the wall, being secured against spreading by the tie A B, the reaction A E will be replaced by the two components, A I, the upward supporting force of the wall, and A G, the stress exerted on the tie; but these two forces give the same stress on the rafter as before.

Consider, next, the method by diagram. The load is now to be concentrated at the joints, and we shall have, in place of E G, A N and C P, each one-half of the load on one rafter. Lay off 1-2 to represent the total load on the roof, make 1-3 = A N, 1-4 = A I, and draw 3-5 and 4-5 parallel to the rafter and tie. A G will equal 4-5, and therefore the stress on the tie is given correctly; but, since A I — A N = A K = 3-4, 3-5 equals A D, and this is the stress given by the diagram as existing from A to C, a supposition which is true when the load is actually concentrated at the joints, but is not true for a distributed load. But A D or 3-5, is equal to one-half of A F + F C, and is manifestly the value of the direct compression at the point D of the rafter; all of the load from A to D was, when we drew the diagram, considered to be concentrated at the joint A.

The load on the principal rafters of a roof-truss is generally concentrated at a series of equidistant points, by means of the *purlins*, or short cross-beams which extend from one truss to another, and are themselves weighted at a series of points by the pressure of the secondary rafters. These secondary rafters, when employed, carry the boards, etc., and thus have a uniformly distributed load. It is only in cases where purlins rest at other points than the *so-called* joints in the principal rafters, that bending action occurs, or in very light trusses where the boards are nailed directly to the main rafters.

It will first be well, even at the risk of dwelling on what is well known to many, to explain what *bending moment* and *moment of resistance* are. A beam A B, Fig. 23, supported at its two ends, when loaded with a series of weights, distributed in any manner, is in equilibrium under the action of vertical forces, the weights acting downwards and the two supporting forces acting upwards. The supporting forces are easily calculated by the principle of the lever, or by taking moments, as explained for Figs. 13 and 16. As the beam is at rest, there must be no tendency to rotate, and therefore, if we assume any point for an axis, the sum of the moments, that is, of the products of each force by its distance from the axis, must equal zero. A moment which tends to produce rotation in one direction being called plus, one which acts in the other direction is called minus. If then we pass an imaginary vertical plane of section through any point in the beam, such as E, the sum of the moments on one side of the plane of section must balance or equal that on the other. The sum of these moments on one side or the other is called the *bending moment*: why will be seen soon.

These moments can balance one another only through the resistance of the beam at the section in question, or of the stresses exerted between the particles cut by this section which resist the tendency to bend the beam. The beam becomes slightly convex, and the particles on the convex side are extended, while those on the concave side are compressed. Experiment shows that, for flexure with such moderate limits as occur in practice, the horizontal forces exerted between contiguous particles vary uniformly as we go from the top of the beam to the bottom, the compressive stress being most intense on the concave side, diminishing regularly to zero at some point or horizontal plane, called the neutral axis, then changing to tension and increasing as we approach the convex side.

Since all of the external forces are vertical, these internal stresses, being horizontal, must balance in themselves, or the total tension must equal the total compression, whence it follows that the neutral axis must pass through the centre of gravity of the section. To make this clear, let one consider how the centre of gravity or the position of the resultant of parallel forces is found, (Compare

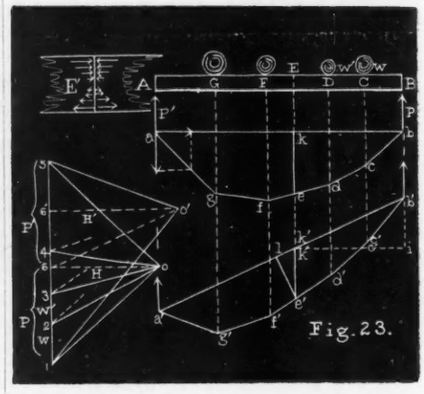


Fig. 16.) We multiply each force or weight by its distance from any assumed axis, and divide by the combined weights. Now if we attempt to find the centre of gravity of a thin cross-section of this beam, and should take our axis at the point where the centre of gravity happens to lie, we can see that the distance of each particle from the axis will vary exactly as these given stresses; hence the neutral axis must lie in the centre of gravity of each cross section.

As these stresses are caused by the resistance to the bending moment on each side of the section, the moment in the interior of the beam made up of the sum of the stress on each particle, multiplied by its distance from the neutral axis, or indeed from any axis, and known as the *moment of resistance*, must equal the bending moment at the given section. The two sets of stresses reacting against each other may be represented to the eye by the arrows in the vertical section marked E'. As the tensions and compressions on one side of the plane of section tend to produce rotation about the neutral axis in the same direction, their moments are added together. The bending moment, then, in the beam A B of the figure, at any section E, will be, if P is the supporting force on the right, W, W', etc. the weights,

$$P.BE - W.CE - W'.DE,$$

or in general, if L equal the arm of any weight, and Σ be the sign of summation,

$$M \text{ (the bending moment)} = P.BE - \Sigma W.L,$$

it being remembered always to take only the weights between one end and the plane of section.

Entered according to Act of Congress, in the year 1875, by Charles E. Greene, in the Office of the Librarian of Congress, at Washington.

If the reader will take a special case, and having a beam of known length, with weights in given positions, will find first the supporting forces, and then calculate the bending moment on either side of a plane of section, he will obtain the same result with opposite signs, showing that the two moments balance one another. The numerical result, being the product of two quantities, is read as so many foot-pounds or inch-pounds, according to the units employed. As the stress on any material is usually expressed in pounds on the square inch, the latter units are the better. The moment of resistance being numerically equal to the bending moment, and therefore equal to the above expression, it is practicable, for a given beam and load, to determine the maximum stress at any section, or, knowing the proper working stress to which to subject the material, to determine the required cross-section.

The weights on one side of the section may all be considered to be concentrated at their common centre of gravity, or point of application of their resultant, so far as the bending moment at that section is concerned, and when the load is continuous, it is always so taken.

SACRAMENTO, Feb. 14, 1876.

EDITOR NEWS: — Will you please ask city engineers and surveyors to inform us through your columns, what are the laws under which their streets are improved, stating whether the laws are enforced in full or whether they can be defeated by litigation. I will discharge my duty now in part.

Sacramento, Cal. — Grading and paving streets is done by the city, and the property owners are assessed and pay for the improvement in proportion to their frontage on the street. Our city business is transacted by three trustees and they may declare their intention to improve any street, publishing 10 days, after which time, if owners of a majority of feet frontage do not protest, they may proceed, after due notice, to let the contract to the lowest responsible bidder, and assess the owners of the property fronting such street at such sum per front foot as will pay the expenses of the improvement. Or, a majority of frontage may petition the Board of Trustees to grade or pave, and then it is imperative on them to proceed.

The street must be improved not less than a block in extent, from the centre of one cross street to the centre of the next, and the whole width from sidewalk to sidewalk, no partial grading or paving, and the expense of the whole block divided equally, per front foot, without regard to what may be done opposite each one's premises. Repairing and sprinkling is done by the city out of a street fund assessed for that purpose on all the property of the city.

Our Supreme Court has decided that the laws cannot be enforced, on the principle that the assessments do not bear equally on each property owner, or according to the benefit conferred, and our city charter relative to street improvements is now being revised, and we hope improved, by the Legislature, of which I may advise you.

J. R. R., *City Surveyor.*

SELECTED LIST OF PATENTS

For the week ending February 18th, 1876.

Relating to Mining, Metallurgy, Engineering, &c., reported for ENGINEERING NEWS by Louis Bagger & Co., Solicitors of Patents, Washington, D. C.

172,836. Cupola Furnaces. E. Voisin, Bourges, France,

These are specific arrangement and relative size of tuyeres, whereby gases are all consumed inside of the furnace. No flame projects at the throat of the furnace. Molten metal sets back into a rear reservoir, and when drawn off floats out over the bottom of the furnace.

172,864. Brick Machines. C. S. Bigler, Harrisburg, Pa.

Clay is forced from the hopper successively into the recesses within the mold-table, by the revolution of which the brick is compressed, and the surplus clay planed off by a knife connected to the frame.

By means of the ascending ways the brick gradually emerges from the mold-table, and is swept off by the sweep onto the rest-table, and thence on the carrying belt.

172,873. Time Signals for Railways. H. H. Ford Sanford Me.

The passing train operates mechanism to turn a signal wheel, which has sand running from one compartment to another, to indicate approximately the time since the wheel was turned.

172,875. Machines for Mining Coal, etc. Jas. Gallicher, Canton, Ohio.

A tooth-wheel on a horizontal axis gears with a pinion, the shaft of which, by a crank, reciprocates horizontally a saw, the whole in a frame on ways. The feed movement is given by a screw-threaded drum (forming part of the main tooth-wheel) gearing with a line of teeth on the floor, and parallel with the ways.

173,881. Gas Taps. Francis St. J Jones, College Yard, Worcester England.

A spiral spring, attached to the handle, serves to keep the plug in its seat, and also locks the plug when closed.

172,877. Water Pressure Regulator. Edward Hays, Rochester, N. Y.

A fixed cap is arranged over the inlet opening to the valve-chamber, to protect the flexible diaphragm.

Contractors' Intelligence.

The contractors have broken ground on the Dublin and Southeastern railroad at Jamestown, Green county, Ohio.

Work has been commenced near Frankfort on the Dayton and Southeastern railroad. Two contracting firms are at work—one with six miles to build and the other with ten.

The contract for building the Vermillion county court house at Danville, Ill. has been awarded to N. E. Terrill, Kankakee city, for $72,969. The bids ranged from that amount to $145,000. Work will begin early in the spring.

The contract for the Iron Work for the new St. Louis Custom House has been awarded to the Union Foundry Works of Chicago, who secured it over seventeen competitors from all over the Union. The same company are furnishing the iron work for the new Custom House in this city.

The *Globe Democrat* complains of the lack of enterprise shown by the capitalists and manufacturers of St. Louis in allowing foreigners to come in and underbid them for St. Louis work.

The special committee of the Peoria county board of supervisors has accepted the plan for a court house offered by Wilcox and Miller, of Chicago. The style and architectural character of the plan is that of the modernized gothic, adapted for the purpose required, and substantially fire-proof. The material is to be sandstone for the exterior, with polished Missouri granite columns. The building is to be complete in all its apartments, and fully equipped with all modern improvements and conveniences. The cost of the structure will be in the neighborhood of $200,000. It is expected that the county will advertise for proposals at once, and work on the building will be commenced at an early day.—*Ill. State Register.*

Proposals for Contracts.

We call the attention of our friends to the importance of the List of Contracts which we are endeavoring to make a feature of our journal, and we request that they will assist us in making it of interest by mailing us local papers containing "Proposals for Contracts," or sending us slips cut from such papers. It takes time to get into good running order, but we will accomplish our purpose after a while to the satisfaction, we trust, of the large number of our readers who are interested in this subject.

TO RAILROAD CONTRACTORS—The "Wheeling and Lake Erie Railroad Company" invite proposals until March 20, 1876 (either separately or combined), for the construction and equipment of its line of road between Martin's Ferry and Sandusky, O., or for parts thereof. Also for railway materials. Particulars furnished on application. Joel Wood, *President.*

Martin's Ferry, O., Feb. 22, 1876

COUNTY JAIL.—The undersigned committee will receive sealed proposals for the erection of a county jail and jailer's residence in the city of Macomb, county of McDonough, Illinois, from the 25th day of February, 1876, to Tuesday, the 14th day of March, 1876. The proposals must be filed in the office of the county clerk of said county on or before 12 o'clock noon of Tuesday, the 14th day of March, 1876. Wm. C. McLeod, John Watson, D. M. Wyckoff, R. McClure, C. V. Chandler, *Committee.*

Macomb, Ill., Feb. 14th, 1876.

COURT HOUSE.—Sealed proposals for the erection of a court house for Story county, Iowa, will be received at the office of the undersigned in Nevada, Iowa, until 12 o'clock, noon, March 15th, 1876. Plans and specifications will be on file in the Auditor's office at Nevada, Iowa, on and after March 1st, 1876. John R. Hays, *County Auditor.*

PROPOSALS FOR SEWER PIPE.—Proposals will be received at Sewer Department, City Hall, Boston, till March 1 for the whole or any part of 20,000 feet of 12-inch vitrified sewer pipe, including 1,000 6-inch branches. Apply as above for specification and form of proposal. Clinton Viles, *Chairman Committee on Sewers.*

PROPOSALS FOR IRON.—Sealed proposals are invited to furnish, delivered at this Arsenal, the following: 30,000 lbs. of 12-inch wrought iron I beams. 85,000 lbs. of 7-inch wrought iron deck beams. 105,000 lbs. of 4-inch wrought iron I beams. 20,000 lbs of T iron from 2½ in. x 3½ in. to 2½ in. x 5½ in. 56,000 lbs. of round bar iron from ⅜ in. to 2¼ in. diameter. 38,000 lbs. of flat and square bar iron, various. Proposals will be opened at 10 a. m. March 10, 1876. For full bill of iron, specifications for quality, and other information, apply to the undersigned. D. W. Flagler, *Major of Ordinance.*

Rock Island Arsenal, Ill. Jan. 29, 1876.

ELECTRICIAN WORK.—Proposals for the electrician work for the new Capitol, at Lansing, Michigan, including all the necessary apparatus for the lighting of the gas, also for operating the call bells, annunciators, etc.—either separately or in connection with the gas lighting—will be received by the Board of State Building Commissioners until 12 o'clock noon on Tuesday, March 7, 1876, and will be opened at the office of E. E. Myers, architect, Detroit, at 8 o'clock p. m. of same day. John J. Bagley, *Governor.* E. F. Grosvenor, James Shearer, Alex Chapoton, *State Building Commissioners.* Allen L. Bours, *Secretary.*

Lansing, Mich., February 4, 1876.

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Extract from report of Committee of Civ. Engs. appointed by Franklin Inst. to examine H. & B.'s new Transit (Dec. 1871): "It exhibits several novelties of construction which, in the opinion of the committee, render it superior to those now in use, and in its opinion the deviations which they have made from the common styles of Transit are decided improvements." JOHN C. TRAUTWINE, Chairman.
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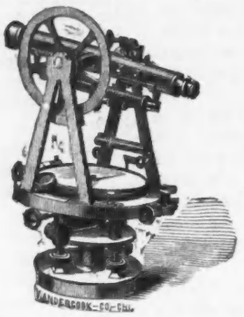

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Wm. B. Howard,
Room 16, Metropolitan Block, Chicago.

J. E. Miller & Co.
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Ray & Whitney,
West end 12th Street Bridge, Chicago, Ill.

Steel & McMahon,
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Busse & Sturtevant,
126 Dearborn Street, Chicago.

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Cox Brothers,
1630 Prairie Avenue, Chicago.

Pavements.

D. D. McBean,
Room 4, 79 Dearborn Street, Chicago, Ill.

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77 Clark Street, Chicago.

J. B Smith,
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